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Group problem solving proficiency as a function of response patterns.

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Introduction

The presumed superiority of group to individual problem solving has often been attributed to the greater number of different responses available within groups and to group-fostered inter-individual facilitation. Presumably the greater number of different responses available within groups increases the probability of occurrence of responses necessary for correct solution. It has been assumed that over and above simply bringing individuals with different responses together, inter-individual interaction in the group situation further increases the number of available responses and thus the probability of occurrence of responses required for solution. The interaction of the group situation may also introduce other, as yet unspecified, sources of facilitation.

Those studies which have been concerned with the influence of responses available within groups introduced this factor after the fact. That is, the nature and strength of responses available to members of the group were not specified before observations of their performance as a group. Then specification was made in terms of probability of the presence of solvers rather than of probability of correct responses. The primary problem of the present study was, therefore, to relate group problem solving to responses which individual members possess upon introduction to the group situation. Further, the strengths of those responses were specified prior to the individual's participation in the group task. An additional concern was to compare the performance of groups composed of individuals with responses of known strength with the performance of non-interacting individuals with comparable response strengths. The baseline for this comparison was the performance of so-called "nominal groups" made up of individuals who performed alone and were then assembled into pairs whose response patterns were the same as those of individuals who had performed in groups.

Although little directly relevant literature is available, a number of investigations of group problem solving will be described in order to provide some background for the description of the present problem. Of particular interest are those studies concerned with group versus individual problem solving. These will be considered in terms of three presumably increasing levels of inter-individual interaction: (a) statistical, in which there is no interaction or in which _S_s respond in the presence of others; (b) perceptual, in which _S_s observe the responses of others but there is no verbal communication; (c) communicative, in which _S_s engage in verbal communication and may also observe the responses of others.

Background Studies

Statistical interaction.--Gordon (4,5,6), Stroop (24), Bruce (1), and Preston (21) have demonstrated that the larger the number of individual judgments of the rank order of objects which enter into group judgments obtained by averaging those rankings, the greater the validity of the composite judgment. But this effect can be produced in the absence of any interaction of Ss and can be demonstrated using chance orders of cards. In a similar study, Klugman (14) required children to estimate individually the contents of jars filled with various materials. Group judgment in the form of means of individual scores was superior to individual judgments. These results were also due to the greater number of independent judgments entering into the group solution. In such studies, therefore, the superiority of group to individual judgments has been a statistical consequence of increasing the number of independent judgments rather than the outcome of behavioral interaction.

Perceptual interaction.--Two studies by Gurnee (8,9) compared group problem solving with pooled individual solutions under conditions intended to preclude discussion and other forms of communication among members of groups. In the first study (8), groups voted on the choice to be taken at each choice point of a bolthead maze. On trials 2-6, groups made significantly fewer errors than controls who worked alone. On trial seven, however, when members of groups worked individually they made almost as many errors as controls. Gurnee suggested, therefore, that the superiority of groups was due to the scattering of individual errors. In the second study (9), five groups of varying size were presented with one of two true-false tests or a test with three alternative items. All items were answered individually first and then voted on by _S_s as members of groups. On each task, groups excelled the average individual in performance and equaled or approximated the performance of the best individual. After analyzing individual responses, Gurnee concluded that, since pooling of individual judgments, apart from any collective operation, gave results superior to those of the average individual, the distribution of individual errors was the predominant factor in group superiority. However, pooling could not account for all of the collective superiority since four of the five groups obtained more correct responses than pooling would give. This was attributed to doubtful _S_s delaying their responses long enough to observe the dominant side and vote accordingly.

Communicative interaction.--Watson (33) used word problems to compare the intellectual efficiency of a group in which discussion was permitted with the efficiency of the same individuals working separately. The group product was superior to that of the average individual in the group and to that of the best member of the group. However, only five of 20 cooperative groups produced more words than did the compilation of a group total list based upon individual activity. This result was not explained.

Perlmutter and de Montmollin (20) required groups and individuals to learn two equivalent lists of nonsense syllables. One list was learned while each person worked individually in the presence of two others, the other while the three persons worked together as a group. The average group recalled more words correctly than the average individual and group scores tended to be better than or equal to the best individual scores. The results obtained by pooling the number of different words learned by the three individuals working alone indicated that in some instances all words could have been reproduced by pooling. In other instances, although all words were learned as a group, they could not have been produced by pooling. The sifting out of incorrect responses by a series of rejections and evaluations, and the development of an implicit assignment of certain words to certain members despite instructions to the contrary, were factors which might have accounted for the superiority of the group.

The problems of Thorndike's study (29) required selection of the more favorable of two alternatives. Ss first made individual judgments and then discussed each of the issues with a unanimous decision as the objective. If unanimity was not reached a vote was taken. The mean percentage of correct choices after group discussion was significantly greater than for pooled individual judgments. The explanation given was that the greater confidence of those holding the correct decision tended to swing the decision of others their way.

In a second study Thorndike (30) found that group scores surpassed individual scores on two forms of four problems, the forms differing only in degree of restriction of possible responses. The greater superiority of groups on the less restricted forms of three tests -- vocabulary, limericks, and sentence completion -- was explained in terms of the wider range of possible responses. The fact that the superiority of the group was greater for solution than for construction of crossword puzzles was considered a function of the greater complexity of the construction task.

After reading material on whether or not Ohio's system of giving paroles should be changed, Timmons' (31,32) Ss ranked solutions to the problem on an individual basis. These rankings were then used to pair discussion groups with collections of controls. Groups discussed the problem and then made a group ranking of solutions. Controls reread the materials and individually ranked the solutions. Group solutions were significantly superior to solutions proffered by individuals even after adjusting individual scores for possible influences of averaging or pooling. Proposed as factors which might have contributed to the superiority of the discussors were an increased range of suggestions leading toward a solution, varied interpretation of facts, an increased range of criticism of suggestions and interpretations, and a larger body of information present in the group. All are variations of the view that interaction of individuals within groups increases the number of available responses and hence the probability of correct solution.

Klugman (13) reported that children working in pairs earned significantly higher scores on the Otis Arithmetic Reasoning Test than when working as individuals, but took significantly longer to complete the problems. Presentation, discussion, rejection, and acceptance of a larger number of possible answers by the pairs may have accounted for the results. While Husband (12) found that pairs of Ss did not differ from individual Ss in time required to solve arithmetic problems, pairs took less time for word puzzles and jigsaw puzzles. Conversations of the members of pairs revealed that while they cooperated on the word and jigsaw puzzles, on the arithmetic problems one S tended to do all of the work.

Lorge, et al. (16) compared the goodness of solutions by teams and individuals of a field problem at four different levels of reality. At every level of remoteness solutions of teams were significantly superior to those of individuals. Team superiority was attributed to the fact that they obtained more information by asking E more questions; also, they evolved more fruitful hypotheses than individuals. Using the game of "Twenty questions" as the problem, Taylor and Faust (27) found group performance to be superior to individual performance in terms of number of questions, number of failures, and elapsed time per problem. A broader range of relevant information and greater flexibility in approach in groups were suggested as factors contributing to group superiority.

Shaw (23) compared the solutions by individuals to complex problems involving a number of steps with those of the same individuals working in groups. Individuals were correct in 7% of the solutions attempted and groups in 40%. The superiority of groups was attributed to the checking of individual errors and the rejection of incorrect suggestions in the group. However, Marquart (19) has noted that by considering one individual as a group Shaw failed to allow for the fact that a group solution might be the result of the activity of any one of the individuals rather than of the group as a whole. Taking this into consideration in analyzing her own data for four of Shaw's problems and for four similar problems, Marquart found that the cooperative groups were not significantly superior to "nominal group" controls. A similar analysis of Shaw's data revealed that 40% of the solutions attempted by Shaw's cooperative groups were correct and 30% of the solutions attempted by groups working as individuals were correct. Furthermore, Marquart discovered an alternative solution to one of Shaw's problems which was as good as, if not better than, the one Shaw used.

Considering this the correct solution both cooperative groups and nominal groups in Shaw's experiment solved 43% of the problems.

McCurdy and Lambert (17) have reported two experiments with a problem whose solution required the cooperation of all members of the group. Performance of individuals surpassed that of groups in both experiments, presumably because of the high likelihood that groups contained at least one person who was inattentive to experimental instructions.

Rosenberg, Erlick, and Berkowitz (22) hypothesized that the differential contributions of an individual to different groups would produce variance between groups which could not be accounted for by isolated individual effects. Such differential contributions were designated as the *assembly effect* to distinguish them from the contributions of each member of the group considered separately. Twenty-seven different groups were assembled and performance measures obtained on a group task. Their results indicate that assembly *per se* is a variable in group performance.

Lorge and Solomon (15) used a mathematical probability model to test the hypothesis that the superiority of groups for problems such as Shaw's (23) resulted only from pooling of the abilities of the members rather than from other types of interaction. The predicted ratios of individual solutions to attempts corresponded closely to obtained ratios. A similar model is described by Taylor (25). However, Taylor and McNemar (28) observed that, although such a model may provide an acceptable prediction of group achievement, it remained to be demonstrated that the performance of a group is a result of ability-interaction. In this connection Faust (3) reported that groups were superior to nominal groups on spatial problems but not on verbal anagrams.

In an experiment designed to determine whether group participation when using brainstorming facilitated or inhibited creative thinking, Taylor, Berry, and Block (26) found that the mean number of ideas produced by real groups was significantly larger than the mean number produced by individuals. However, "nominal groups" composed of the same individuals were significantly superior to the real groups in terms of mean number of ideas, mean number of unique ideas, and each of three measures which involved weighting ideas with respect to quality. The superiority of the nominal groups to real groups in number of unique ideas was a result of the superiority of the former in total number of responses. For the three quality measures, the superiority of the nominal groups was largely a matter of the difference in the total number of responses, and only to a limited degree, if any, a matter of differences in the quality of ideas produced.

In summary, at statistical and perceptual levels of interaction the problem solving of groups may be superior to that of individuals, though at the former level such superiority is essentially a statistical rather than a behavioral consequence of group performance. At the communicative level, while the results of Thorndike (29,30), Timmons (31,32), Klugman (13), Husband (12), Lorge, *et al.* (16), Taylor and Faust (27) and Shaw (23) suggested the superiority of groups, those of Watson (33), Perlmutter and de Montmollin (20), Marquart (19), and Faust (3) indicated no differences or were inconclusive, and McCurdy and Lambert (17), and Taylor, Berry, and Block (26) found the performance of individuals to be superior. In addition to inconsistencies with respect to the superiority of groups to individuals, in none of these studies was the distributions of different responses (knowledge, skills) among members of the groups known *a priori*.

Problem

The present study had two primary objectives. The first was to ascertain the relationship of problem solving to patterns of responses necessary for solution of the problem among members of cooperative groups working at the perceptual level of interaction. The second was to determine the relative performance of cooperative and nominal groups matched with respect to patterns of responses. It was hoped that the data bearing on these objectives would contribute to clarification of some of the inconsistencies of previous findings.

Predictions for cooperative groups.--Lorge and Solomon

(15) and also Taylor (25) have proposed models for group problem solving based on the probability that groups would contain members who would be able to solve the problem. Subsequently Goss (7) suggested that the Lorge and Solomon-Taylor models should be elaborated to take into account the properties of specific responses in the particular sequences required for solution. Further, such an extended model should allow for the occurrence of a number of trials. Illustrating, but not completing the desired elaboration, was the expression:

$$p_{R_1R_2}(n) = [1-(1-p_{R_1})^{\underline{n}\ \underline{k}}]\ [1-(1-p_{R_2})^{\underline{n}\ \underline{k}}]\ /2$$

where $p_{R_1R_2}$ represent the probability of occurrence of responses R_1 and R_2 in an R_1R_2 sequence for groups of <u>k</u> individuals on the <u>n</u>th trial with the task. <u>k</u> is the number of individuals who possess each response at a probability greater than 0.00.

Since $(1-p_{R_1})$ and $(1-p_{R_2})$ are both < 1.00, as <u>n</u> and/or <u>k</u> increase values of these two expressions will decrease. When these increasingly smaller values are subtracted from 1.00 the values within each set of brackets, and therefore their product, will approach 1.00 and the entire expression will approach 1.00/2.00 or 0.50. Thus an increase in the number of individuals or of trials should increase the probability of occurrence of the correct response sequence.

The objectives of the present study were suggested by the considerations giving rise to and expressed in this formula. However, use of the formula for the calculation of specific probabilities of occurrence of the R_1R_2 sequence of the task employed here was precluded by several limitations. First, the model assumes that the probabilities of R_1 (p_{R_1}) and R_2 (p_{R_2}) remain constant from trial to trial. Under the conditions employed here they changed. Second, the formula should be further modified so that $p_{R_1R_2}(n)$ approaches 1.00 rather than 0.50. Third, the R_1 and R_2 of this study each consisted of three more elementary response components, and therefore only approximated the responses assumed by the model. Fourth, without further provisions, the criterion for R_1 and R_2 employed here, which was of the form "_X_ successive correct responses," provides only for relative and not absolute estimates of response probabilities. Fifth, the formula cannot be applied when either R_1 or R_2 has a probability of 0.00. (But for tasks involving the selection of some responses from a finite number of response probabilities, all responses can be considered to have a probability of occurrence greater than 0.00.)

Although the specific formula could not be used for predictions, it was possible to suggest some tentative hypotheses on the basis of the same considerations regarding strengths of two or more responses by _k_ individuals in specific sequences over _n_ trials, for which the formula was an illustrative but, as noted above, limited expression. Thus, if one member of a group had learned R_1 and the other R_2, between them they would have the two responses necessary for solution (R_1R_2 pattern). Remaining to be learned would be that the individual with R_1 should respond first and that the individual with R_2 should then respond.

If both members had R_1 (R_1R_1 pattern), or both had R_2 (R_2R_2 pattern), at least one member would have to learn a a new response after which the members would have to learn the R_1R_2 sequence. Since R_1 has to be made before R_2, the initial tendencies to respond with R_2 might hamper acquisition of the R_1R_2 sequence to a greater degree than acquisition of R_1R_2 might be hampered by initial tendencies to respond with R_1.

When both members of a group possess R_1 or both possess R_2, the probabilities of occurrence of R_1 or R_2, respectively, should be greater than the probabilities of these responses when only one member possesses R_1 (R_1R_0 pattern) or R_2 (R_2R_0 pattern) and the other member has neither response at greater than chance levels. At least one member of these latter groups, as in the former groups, would have to learn a new response after which the R_1R_2 sequence would have to be learned. Because of the higher probabilities of R_1 or R_2, the R_1R_1 or R_2R_2 patterns should have some advantage over the R_1R_0 or R_2R_0 patterns. It seemed possible, however, that the requirement of the occurrence of R_1 before R_2 might occasion faster learning of R_1R_2 with the R_1R_0 pattern than the R_2R_0 pattern. Should the disadvantage of having to respond with R_1 first be sufficiently great, performance with the R_1R_0 pattern might even be better than with the R_2R_2 pattern.

Since both R_1 and R_2 as well as the R_1R_2 sequence must be learned, least rapid learning would be expected with the R_0R_0 pattern. Because R_1 must occur first, however, the R_2R_2 and R_2R_0 patterns might do less well than the R_0R_0 pattern.

The cooperative two-man groups of this investigation represented each one of the six possible patterns of the members' possession of R_1, R_2, or R_0, at the beginning of acquisition of the R_1R_2 sequence. While the R_1R_0 pattern might lead to better performance than the R_2R_2 pattern, and the R_0R_0 pattern to better performance than the R_2R_2 and R_2R_0 patterns, the simplest further assumption was that, whether the responses were R_1 or R_2, patterns in which both members possessed R_1 or R_2 would be better than those in which one member possessed R_1 or R_2 which, in turn, would be superior to the R_0R_0 pattern. Thus, the anticipated order of increasing proficiencies in problem solving was patterns R_1R_2, R_1R_1, R_2R_2, R_1R_0, R_2R_0 and R_0R_0.

Nominal groups.--Information obtained with groups alone does not answer the question of whether performing in groups results in greater proficiency than would be achieved by a like number of Ss working individually. Therefore, nominal groups of Ss were formed, each made up of two Ss who had learned the R_1R_2 criterion task individually. The nominal groups matched the cooperative groups with respect to the patterns of R_1, R_2 and R_0.

Method

Subjects

Two hundred forty males enrolled in the course in introductory psychology at the University of Massachusetts served as Ss. They were first assigned to three training groups and then (on the basis of previous training) either to 60 two-man experimental groups or to 60 two-man nominal groups (pairs of Ss working individually). The members of two-man groups were selected so that they were not friends and had not previously worked together in laboratory situations, clubs, etc. (This information was obtained prior to the experiment by means of a short questionnaire.)

Apparatus

A modification of the apparatus described by McCurdy and Lambert (17) was used. This apparatus was selected because it could be used with either individuals or groups, provided equal opportunity for each individual to contribute to the group solution, permitted training of Ss on various portions of the problem, and allowed accurate recording of responses.

As shown in Figure 1, six three-position telephone type switches, clearly labeled from 1 to 6, were mounted in a row on a horizontal panel together with a white signal light and a red signal light. Connected to this panel was a control panel containing matching lights. A set of programing

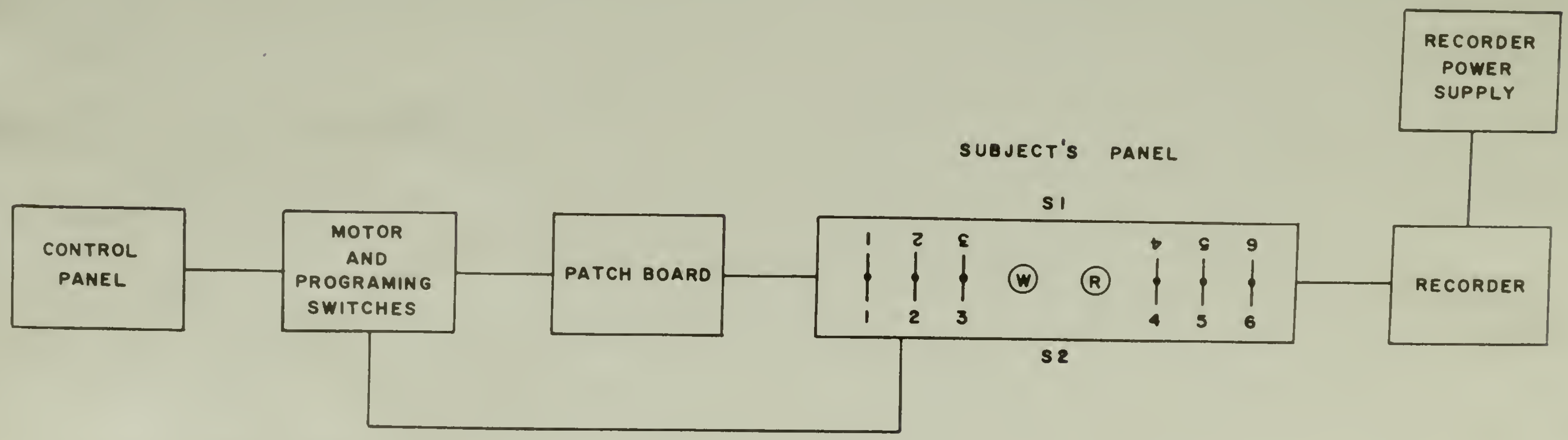

Fig. 1. Block Diagram of Apparatus. S_1 and S_2 indicate positions of subjects.

switches, a constant speed motor, a patch board, a recorder, and the power supply for the recorder were the remaining components.

When the switches on the S's panel were set to correspond to the programing switches the white light flashed on. Any particular sequence or pattern of selection of one or more of the S's switches could be set into the patch board. This was done at the beginning of each experimental session. To begin each trial within a session, E pushed a starting button activating the constant speed motor which turned off the red light and the white light. When the white light went off S began to manipulate the switches and continued to do so until the white light came on again. The motor then automatically set the next programing switch, turning off the white light. When all of the switches had been manipulated in the correct sequence the red light went on and S was considered to have finished that trial. The recording of S's choices was automatic. Eight styli, which marked an electrically responsive charting paper running through a continuously fed kymograph, provided a graphic record of switch movements and also of the cutting on and off of the signal lights. (A detailed description of the construction and operation of the apparatus is given in the Appendix, page 65.)

Procedure

Table 1 summarizes the experimental design. The task

Table 1

Response Patterns in Two-Man Cooperative and Nominal Groups. Ten Two-Man Groups were Formed for each Pattern under each Condition

Condition	Individual	Response Pattern					
		R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
Cooperative	A	R_1	R_1	R_2	R_1	R_2	R_o
	B	R_2	R_1	R_2	R_o	R_o	R_o
Nominal	A	R_1	R_1	R_2	R_1	R_2	R_o
	B	R_2	R_1	R_2	R_o	R_o	R_o

consisted of learning R_1 and R_2 in sequence under cooperative or nominal conditions with response patterns which were combinations of previously learned responses R_1 and R_2, and of what had been designated as R_o experience. The R_o experience, which involved prior exposure to the situation and switches, was designed to control for transfer from sources not specific to R_1 and R_2 (18). _Ss_ came to the group situation after learning either R_1 or R_2 or following the R_o experience.

Preliminary experiment.--The relative difficulty of R_1 and R_2 was determined in a preliminary experiment with 16 _Ss_. Half the _Ss_ learned R_1 and half R_2. Tests of significance of the differences between number of moves required to learn R_1 ($\underline{M}$ = 22.4; _SD_ = 16.1) and R_2 ($\underline{M}$ = 30.4; _SD_ = 33.2) and between the number of errors ($\underline{M}$ for R_1 = 8.1 with _SD_ = 12.1; $\underline{M}$ for R_2 = 13.1 with _SD_ = 21.0) required to learn these responses resulted in _t_'s of 1.62 and 1.51, respectively, neither of which was significant at the .05 level.

Retention of R_1 and R_2 was determined by bringing the _Ss_ back to the task after having been removed from it for 10 minutes. Of the 16 _Ss_, 12 had perfect retention, three reached criterion after one trial, and one _S_ required two trials.

Learning R_1 or R_2; the R_o experience.--Prior to being introduced to the group situation, _Ss_ individually received one of three types of training. One-third of the _Ss_ learned

R_1 and one-third learned R_2 to a criterion of three errorless trials. R_1 consisted of choosing switches 3, 2, and 4 in that order and R_2 of choosing switches 5, 4, and 2. Each of the first two responses which made up R_1 or R_2 was reinforced with a white light; the last choice in each sequence was reinforced by both the white and the red light.

As noted above, the R_0 experience was designed to control for transfer from sources not specific to R_1 and R_2. Learning R_1 or R_2 was expected to involve "getting-used-to" the _E_, the experimental room, and the general features of the apparatus. Presumably such experiences would result in the _S_s paying closer attention to the more specific stimuli, responses, and requirements of the task. Further, learning R_1 and R_2 necessarily involved familiarization with selecting the switches, consequences of such selection, and with choosing the switches in sequence. The R_0 experience was intended to provide a baseline for positive transfer to acquisition of the R_1R_2 sequence arising from these nonspecific sources which, however, did not also involve strengthening R_1 or R_2. The instructions for the R_0 experience were intended to eliminate a "set" to respond "randomly" or by "trial and error." Also, the sequence of switches of the R_0 experience was designed to reduce or eliminate any initial preferences for particular switches or sequences of switches. Thus, efforts were made to eliminate these possible sources of negative transfer from the R_0 experience.

The number of switch movements and trials in the R_o experience was equated with the mean number of trials and switch movements required to learn R_1 and R_2 in the preliminary experiment. This necessitated the distribution of 26 switch movements among five trials. The learning period for each S was broken into Vincent's (11) fifths. The mean number of trials in each fifth was 10.2, 6.1, 3.8, 3.2, and 3.1. Since the last three trials for each S were criterion trials, three switch movements were required in each. After applying this correction, the number of switch movements for each trial became 10, 7, 3, 3, and 3. The particular switches for each trial were selected from a table of random numbers within the limitation that, over the five trials, each switch was to be chosen at least four times. The reinforcement of choices of switches within each trial was as follows: (a) each of the three choices of each of the last three trials were reinforced; the first two of each three by the white light and the last by the white light and the red light; (b) the last choice of the first two trials was reinforced by both the white light and the red light; (c) within the first and second trials two choices were preselected randomly for reinforcement by the white light; and (d) one-half of the choices were reinforced by the white light twice and one-half three times. This series of reinforced and non-reinforced choices on each trial and from trial-to-trial was designated R_o-I. A second series, R_o-II, was also prepared in which those choices which had been reinforced three times in R_o-I were reinforced twice, and those choices which were reinforced twice in R_o-I were reinforced three times. The two series were otherwise identical. (Both R_o-I and R_o-II are given in the Appendix, page 74.)

Half of the Ss receiving the R_o experience were administered R_o-I and half R_o-II. On each trial with these series Ss were instructed to respond by manipulating the switch which corresponded to the number called out by E. Those choices which had been preselected for reinforcement were followed by the white light or the white and the red light. (The instructions administered to the Ss who learned R_1 or R_2 or experienced R_o are given in the Appendix, page 61.)

Learning the R_1R_2 sequence.--The group task, learning of the R_1R_2 sequence, consisted of choosing switches $3 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 4 \rightarrow 2$ in that order. This sequence had been chosen randomly and then arbitrarily divided into 3, 2, 4 for R_1 and 5, 4, 2 for R_2. Each of the first five responses which made up the R_1R_2 sequence was reinforced with the white light, the sixth response being reinforced by both the white and the red light. Half of the Ss who learned R_1 or R_2 or had experienced R_o were used to form two-man cooperative groups which represented the six possible patterns of those responses: R_1R_1, R_1R_2, R_1R_o, R_2R_2, R_2R_o, R_oR_o (Table 1). For each pattern there were 10 pairs. The other half of the

Ss were used to form 10 pairs of nominal groups for each of these patterns.

For the R_1R_2 pattern under the cooperative condition, one member of each pair was first trained with either R_1 or R_2 and then removed from the situation. The second member was then brought in and trained with either R_2 or R_1, after which the first S was returned for the cooperative learning of the R_1R_2 sequence to a criterion of three errorless trials. The prior training was counterbalanced so that in half of these pairs R_1 had been learned first and in the other half R_2 had been acquired first. Within the R_1R_2 pattern and also within the other response patterns (Table 1) the positions of the Ss of each pair relative to the apparatus were counterbalanced so that for half of the pairs the member who learned R_1 or R_2 first was at position S1, and for the other half of the pairs that member was at position S2 (Figure 1).

For the R_1R_1, R_2R_2, and R_oR_o patterns under the cooperative condition one member of the pair learned R_1 or R_2 or experienced R_o and then waited while the other member learned R_1 or R_2 or experienced R_o, respectively. Both then learned the R_1R_2 sequence to the three errorless trials criterion.

The R_1R_o and R_2R_o patterns under the cooperative condition were formed in the same way as the R_1R_2 pattern. One member learned R_1 or R_2, or experienced R_o, and waited while the other member experienced R_0, or learned R_1 or R_2. Since the mean time required for Ss to learn R_1 or R_2 was slightly less than five minutes, as indicated by the preliminary experiment there should have been little or no forgetting of R_1 or R_2 by Ss who had learned R_1 or R_2 and then waited.

In order to maintain interaction at an elementary level and to provide a baseline for subsequent comparisons, verbal and perceptual interaction of the cooperative Ss was restricted. This was accomplished by instructing the Ss not to talk to each other and by erecting a 30" x 25" barrier between the two Ss. A 20" x 4" opening permitted each S to observe his partner's responses but obstructed observations of facial expressions and other body movements.

Ss comprising the nominal groups had first learned R_1 or R_2 or had the R_0 experience. They then worked alone in learning the R_1R_2 sequence to the criterion of three errorless trials. Time lapses between training and experimental periods were equated with those for the members of the cooperative groups. This was accomplished by requiring Ss to wait five minutes before subjecting them to the learning of the R_1R_2 sequence. (The instructions for learning the R_1R_2 sequence administered to cooperative and nominal groups are given in the Appendix, page 61.)

The Ss were run in 10 cycles of 24 Ss each. Twelve Ss within each cycle were assigned to the six patterns under the cooperative condition; the remainder were assigned to the six patterns under the nominal condition. Within each cycle the order in which the patterns were run was randomized.

Results

Learning R_1 or R_2.--Number of trials, moves, and errors to criteria were the measures of learning of R_1 or R_2 separately and of the R_1R_2 sequence. The first concern was whether there were any differences in the learning of R_1 or R_2 by Ss of the cooperative or nominal groups which contained Ss, one or both of whom had learned R_1 or R_2. Table 2 shows the means and standard deviations of trials, moves, and errors to criterion for the learning of R_1 by those Ss who were in the R_1R_2, R_1R_1, and R_1R_0 patterns under cooperative or nominal conditions. Also shown are the means and standard deviations for the same measures for the acquisition of R_2 by Ss who were in the R_1R_2, R_2R_2, and R_2R_0 patterns under cooperative and under nominal conditions.

Simple randomized design analyses of variance were used to ascertain the significance of the differences among means of trials, moves, and errors in the learning of R_1 by the three groups of Ss in the R_1R_2, R_1R_1, and R_1R_0 patterns under cooperative and under nominal conditions. Similar analyses were carried out for the learning of R_2. As shown in Table 3, none of the F's of these four analyses approached significance at the .05 level. Accordingly, because the Ss, in R_1R_2, R_1R_1, and R_1R_0 under cooperative conditions did not differ in their learning of R_1, scores for these Ss on their learning measures were pooled. Scores for Ss under nominal

Table 2

Means and Standard Deviations of Trials, Moves, and Errors to Criterion under Cooperative and under Nominal Conditions for Learning R_1 in Response Patterns R_1R_2, R_1R_1, and R_1R_o, and for Learning R_2 in Response Patterns R_1R_2, R_2R_2, and R_2R_o

		Learning R_1 for Response Patterns						Learning R_2 for Response Patterns					
Measure	Condition	R_1R_2		R_1R_1		R_1R_o		R_1R_2		R_2R_2		R_2R_o	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Trials	Cooperative	2.00	1.79	2.80	2.98	2.80	2.64	2.60	2.29	2.35	1.65	2.40	1.28
	Nominal	2.20	1.25	4.05	5.11	3.56	1.89	2.10	0.83	2.55	1.47	4.00	5.16
Moves	Cooperative	13.10	6.30	21.10	21.45	22.80	18.41	21.40	17.90	18.30	8.08	22.20	9.14
	Nominal	15.00	6.69	32.05	41.16	26.90	15.26	17.20	6.43	22.60	13.73	33.90	39.24
Errors	Cooperative	7.10	3.56	12.70	12.96	14.40	12.27	13.60	11.44	10.80	3.60	15.00	5.93
	Nominal	8.40	4.03	19.90	26.14	17.30	9.75	10.90	4.81	14.95	9.51	21.90	23.99

Table 3

Analyses of Variance for Response Patterns for Groups Learning R_1 or R_2 under Cooperative and under Nominal Conditions for Trials, Moves, and Errors to Criterion

Group	Source	df	Trials		Moves		Errors	
			MS	F	MS	F	MS	F
R_1 - Cooperative	Response Patterns (P)	2	2.40	0.32	284.84	0.78	152.24	1.13
	Error	37	7.54		364.49		134.91	
R_1 - Nominal	P	2	11.61	0.75	970.08	0.98	446.54	1.12
	Error	37	15.52		991.02		399.47	
R_2 - Cooperative	P	2	0.21	0.06	62.85	0.43	66.15	1.28
	Error	37	3.33		144.49		51.88	
R_2 - Nominal	P	2	10.28	1.20	740.74	1.40	313.01	1.49
	Error	37	8.54		529.22		210.67	

conditions who had learned R_1 were also pooled as were those of the Ss under cooperative and under nominal conditions who had learned R_2.

The means of trials, moves, and errors for those pooled scores (Table 4) were then compared by means of a 2 x 2 orthogonal analysis of variance in which R_1 or R_2 was one factor and cooperative or nominal conditions was the other factor (Table 5). None of the F's for these factors or their interactions for any of the three measures was significant at the .05 level. Thus R_1 and R_2 were learned at the same rate, and there were no differences between Ss of the cooperative and those of the nominal conditions in rates of learning the two responses.

Learning the R_1R_2 sequence.--The learning of the R_1R_2 sequence by Ss of the cooperative groups was expressed as the number of trials, moves, and errors to criterion for the two Ss of a group working together. The scores for the nominal groups were the averages of trials, moves, and errors to criterion of the two members of each of the 10 arbitrary pairs for each of the response patterns. The means and standard deviations of these measures for each of the response patterns under cooperative and under nominal conditions are presented in Table 6 and plotted in Figure 2. The coefficients of concordance for the three measures under the cooperative condition was .94 and that for these measures under the nominal condition was .96. Both were

Table 4

Means and Standard Deviations of Trials, Moves, and Errors to Criterion under Cooperative and under Nominal Conditions for Learning R_1 and R_2

Response	Trials				Moves				Errors			
	Cooperative		Nominal		Cooperative		Nominal		Cooperative		Nominal	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
R_1	11.73	11.51	16.38	19.79	19.53	18.75	26.50	31.07	2.60	2.66	3.38	3.86
R_2	12.55	7.16	15.68	14.51	20.05	11.66	24.08	22.95	2.43	1.76	2.80	2.90

Table 5

Analyses of Variance for R_1 or R_2 and Conditions for Trials, Moves, and Errors to Criterion

Source	df	Trials		Moves		Errors	
		MS	F	MS	F	MS	F
Response (R)	1	5.63	0.65	36.10	0.07	0.15	0.00074
Conditions (C)	1	13.23	1.54	1,210.00	2.38	604.50	3.00
R x C	1	1.59	0.18	87.02	0.17	23.27	0.12
Error	156	8.60		507.68		201.55	

Table 6

Means and Standard Deviations of Trials, Moves, and Errors to Criterion for Each Response Pattern under Nominal and under Cooperative Conditions

Pattern	Trials				Moves				Errors			
	Cooperative		Nominal		Cooperative		Nominal		Cooperative		Nominal	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
R_1R_2	3.00	2.68	3.95	2.14	28.00	21.26	44.85	23.44	10.00	6.63	21.15	11.59
R_1R_1	3.70	2.05	4.05	2.62	37.30	16.41	45.15	26.85	15.10	5.34	20.85	11.61
R_2R_2	4.30	2.45	3.95	2.08	49.80	23.64	42.50	21.19	24.00	10.25	18.80	9.49
R_1R_o	9.70	4.41	5.00	2.22	97.70	41.48	59.45	23.83	39.50	16.76	29.45	11.38
R_2R_o	7.50	3.69	4.05	1.31	87.20	40.82	52.00	15.52	42.40	20.99	27.70	8.47
R_oR_o	9.00	4.86	5.80	2.39	103.80	48.19	70.95	33.39	49.80	21.33	36.25	20.29

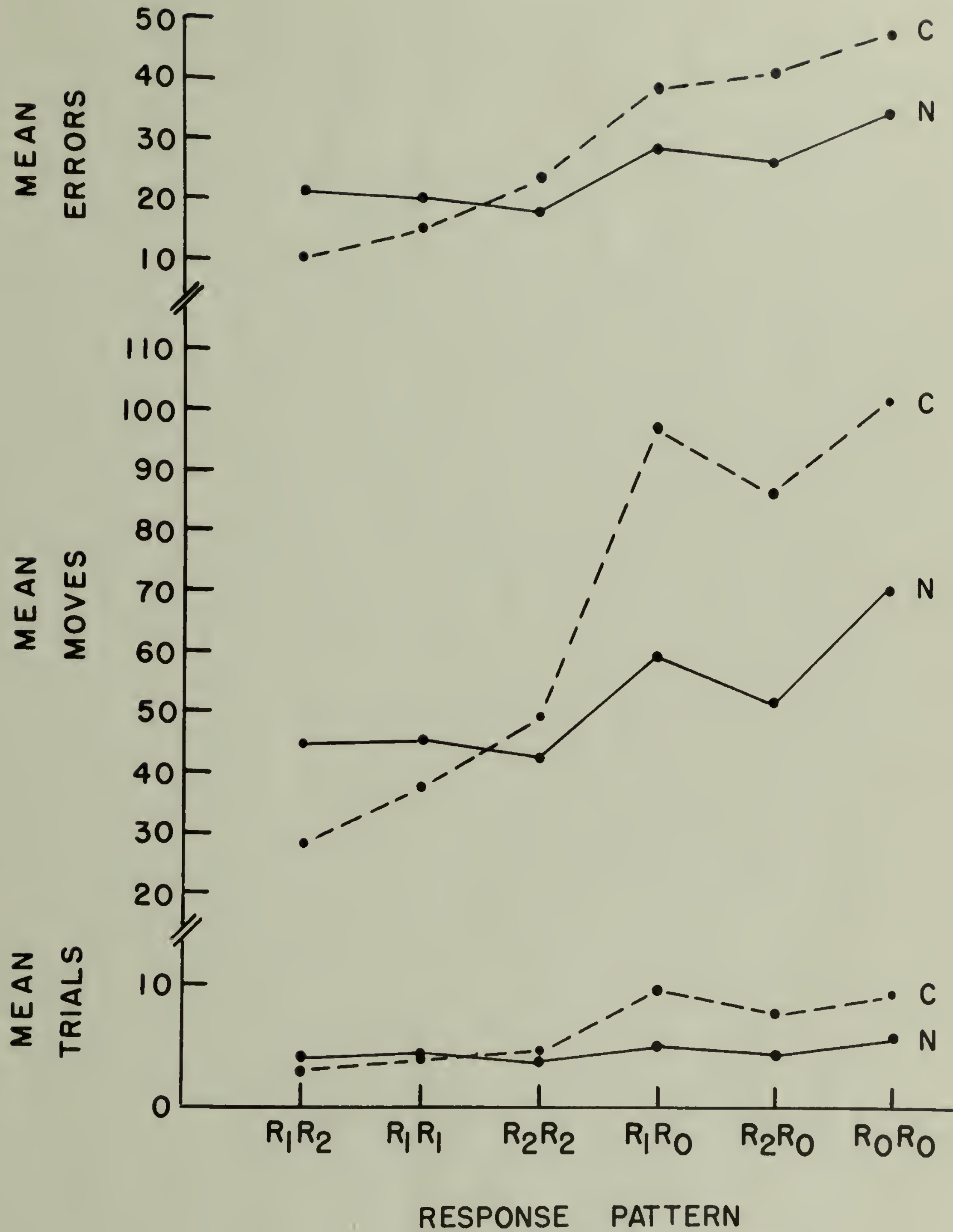

Fig. 2. Mean trials, moves, and errors to criterion under the cooperative (C) and under the nominal (N) condition for each response pattern.

significant at less than the .01 level. Regardless of the measure, means of the R_2R_2, R_1R_o, R_2R_o, and R_oR_o groups under the nominal condition were lower than the means of the same patterns under the cooperative condition. For the R_1R_2 and R_1R_1 patterns the means were lower under the cooperative than under the nominal condition.

Response patterns and cooperative or nominal conditions were the factors of the analyses of variance summarized in Table 7. Hartley's (10) test of homogeneity of variance was significant at less than the .05 level for errors and trials. Since the .01 level was not reached the variances were accepted as homogeneous. A more conservative approach is to consider the variances heterogeneous and to employ .025 or less rather than .05 or less levels of significance. The interpretation of the results remains the same.

For all three measures the $\underline{F}$'s for response patterns were significant at less than the .01 level. Disregarding the cooperative and nominal conditions, whether measured by trials, moves, or errors the R_1R_2 pattern led to the most rapid acquisition of the R_1R_2 sequence; the slowest learning was by $\underline{S}$s in the R_oR_o condition. The R_1R_1, R_2R_2, R_2R_o, and R_1R_o response patterns required increasingly more trials and moves to criterion. The same order was obtained for errors with the exception that more errors occurred with R_2R_o than with R_1R_o.

Table 8 summarizes the results of Duncan Multiple-Range

Table 7

Analyses of Variance for Response Patterns and Conditions for Trials, Moves, and Errors to Criterion

Source	df	Trials		Moves		Errors	
		MS	F	MS	F	MS	F
Response Patterns (P)	5	62.29	6.58**	9,146.46	9.29**	2,463.11	11.44**
Conditions (C)	1	90.14	9.52**	6,586.01	6.69*	589.64	2.74
P x C	5	27.35	2.89*	2,862.36	2.91*	567.19	2.63*
Error	108	9.47		984.57		215.39	

* Significant at .05 level.
** Significant at .01 level.

Table 8

Differences Between Pairs of Response Patterns for Trials, Moves, and Errors to Criterion Significant at the .05 Level in Duncan Multiple-Range Tests

Trials			Moves			Errors		
R_1R_o	>	R_1R_2	R_1R_o	>	R_1R_2	R_1R_o	>	R_1R_2
		R_1R_1			R_1R_1			R_1R_1
		R_2R_2			R_2R_2			R_2R_2
R_2R_o	>	R_1R_2	R_2R_o	>	R_1R_2	R_2R_o	>	R_1R_2
					R_1R_1			R_1R_1
					R_2R_2			R_2R_2
R_oR_o	>	R_1R_2	R_oR_o	>	R_1R_2	R_oR_o	>	R_1R_2
		R_1R_1			R_1R_1			R_1R_1
		R_2R_2			R_2R_2			R_2R_2
								R_1R_o

Tests (2) of differences between the means of pairs of response patterns for trials, moves, and errors. With the exception that means of trials to criterion with the R_1R_1 and R_2R_2 patterns did not differ from the mean for the R_2R_0 pattern, rates of learning for all three measures with the R_1R_2, R_1R_1, and R_2R_2 patterns were significantly better at the .05 level than the rates with the R_1R_0, R_2R_0, and R_0R_0 patterns. The former three patterns did not differ among themselves, nor, with the exception of significantly fewer errors with the R_1R_0 pattern than with the R_0R_0 pattern, were there any differences among the latter three patterns.

Summing over response patterns, fewer trials, errors, and moves to criterion were required under the nominal than under the cooperative condition. While the $\underline{F}$ for errors was not significant those for trials and moves were significant at less than the .01 and .05 levels, respectively.

The $\underline{F}$'s for the interactions of response patterns and conditions were significant at less than the .05 level. These $\underline{F}$'s all reflected the somewhat lower means of trials, moves, and errors with the R_1R_2 and R_1R_1 response patterns under the cooperative than under the nominal condition, and the somewhat higher means for all these response measures with the remaining four patterns under the nominal than under the cooperative condition. Because of the significance of the $\underline{F}$'s and the very similar relationship between the profiles for the six response patterns under cooperative and under nominal conditions for all three measures, F's were computed for the effects of response patterns under cooperative and under nominal conditions separately (Table 9).

The F's for differences among the response patterns under the cooperative conditions for trials, moves and errors were each significant at less than the .01 level. The Duncan Range Test was used to specify the differences between the means of pairs of response patterns which were significant at the .05 level (Table 10). The R_1R_2, R_1R_1, and R_2R_2 patterns required fewer moves and errors to criterion than did the R_1R_0, R_2R_0, and R_0R_0 patterns. Fewer errors were made with the R_1R_0 than with the R_0R_0 pattern. For trials, the R_1R_2, R_1R_1, and R_2R_2 conditions were superior to the R_1R_0 and R_0R_0 patterns, and the R_1R_2 and R_1R_1 patterns led to more rapid learning than the R_2R_0 pattern. None of the other differences was significant.

Under the nominal condition only the F of 2.46 for errors was significant at the .05 level. For trials and moves to criterion the F's were not significant. The Duncan Range Test indicated that there were fewer errors to criterion with the R_1R_2, R_1R_1, and R_2R_2 patterns than with the R_0R_0 pattern.

To be significant at the .05 level the means of trials, moves, and errors for a response pattern under cooperative conditions and for the same patterns under nominal conditions

Table 9

Analyses of Variance for Response Patterns under Cooperative and under Nominal Conditions for Trials, Moves, and Errors to Criterion

Condition	Source	df	Trials		Moves		Errors	
			MS	F	MS	F	MS	F
Cooperative	Response Patterns (P)	5	83.76	6.10**	10,806.32	8.35**	25,879.91	10.32**
	Error	54	13.72		1,294.46		250.77	
Nominal	Response Patterns (P)	5	5.89	1.13	1,203.00	1.78	442.40	2.46*
	Error	54	5.21		674.68		180.02	

* Significant at .05 level.
** Significant at .01 level.

Table 10

Differences Between Pairs of Response Patterns under Nominal and under Cooperative Conditions for Trials, Moves, and Errors to Criterion Significant at the .05 Level in Duncan Multiple-Range Tests

Condition	Trials	Moves	Errors
Cooperative	$R_1R_o > R_1R_2$, R_1R_1, R_2R_2	$R_1R_o > R_1R_2$, R_1R_1, R_2R_2	$R_1R_o > R_1R_2$, R_1R_1, R_2R_2
	$R_2R_o > R_1R_2$, R_1R_1	$R_2R_o > R_1R_2$, R_1R_1, R_2R_2	$R_2R_o > R_1R_2$, R_1R_1, R_2R_2
	$R_oR_o > R_1R_2$, R_1R_1, R_2R_2	$R_oR_o > R_1R_2$, R_1R_1, R_2R_2	$R_oR_o > R_1R_2$, R_1R_1, R_2R_2, R_1R_o
Nominal			$R_oR_o > R_1R_2$, R_1R_1, R_2R_2

should differ by 2.72, 27.79, and 12.99, respectively. Significantly fewer errors were made with the R_2R_0 pattern under the nominal than under the cooperative condition as was the case for the R_0R_0 pattern (Table 11). For both trials and moves, the R_1R_0, R_2R_0, and R_0R_0 patterns under the nominal condition led to faster learning than did the same patterns under the cooperative condition. Although the R_1R_2 and R_1R_1 patterns required fewer trials, moves, and errors to criterion under the cooperative than under the nominal condition, none of the differences was significant.

In summary, there were no differences with respect to acquisition of R_1 or R_2. Under the cooperative condition the R_1R_2 pattern led to the most rapid learning followed by R_1R_1, R_2R_2, R_2R_0, R_1R_0, and R_0R_0 in that order. The R_1R_2 and R_1R_1 patterns under the cooperative condition were somewhat, but not significantly, more efficient than the corresponding patterns under the nominal condition. The remaining patterns were poorer than the corresponding patterns under the nominal condition. In general, differences among the six patterns under the nominal condition were not significant.

Table 11

t Tests for Differences Between Pairs of Nominal and Cooperative Patterns for Trials, Moves, and Errors to Criterion

Group	Cooperative	R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
	Nominal	R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
Difference	Trials	0.95	0.35	0.35	4.70*	3.45*	3.20*
	Moves	16.85	7.85	7.30	38.25*	35.20*	32.85*
	Errors	11.15	5.75	5.20	10.05	14.70*	13.55*

* Significant at .05 level.

Discussion

The learning of R_1 and R_2 will be considered first. Acquisition of the R_1R_2 sequence under the cooperative condition will then be examined in terms of (a) the anticipated order of effectiveness of the response pattern, (b) transfer of training, and (c) possible interactive effects of each member on the other. Finally, implications for theory and experimentation on group problem solving will be explored.

Learning R_1 or R_2.--Since R_1 and R_2 required the same number of trials, moves, and errors to criterion they can be considered of equal difficulty; this result was consistent with the findings of a preliminary investigation. Any subsequent differences associated with the R_1R_2 responses, therefore, could be attributed to differences in subsequent patterns into which R_1 and R_2 entered and not to any differences in their difficulty or in their strengths at the end of the training phase.

Also, the Ss who were assigned to the different response patterns under cooperative or nominal conditions did not differ in their rates of learning either R_1 or R_2. Thus, any subsequent differences in the acquisition of the R_1R_2 sequence associated with particular combinations of patterns and conditions could not be attributed to differences in the learning ability of the Ss or in their mastery of R_1 and R_2.

Learning the R_1R_2 sequence.--Under the cooperative condition, the most rapid learning was obtained with the R_1R_2 pattern whether measured by trials, moves, or errors to criterion. With the exception of trials, for which the R_1R_0 pattern was slowest, the least rapid learning occurred with the R_0R_0 pattern. However, the R_1R_2 pattern was not significantly better than the R_1R_1 and R_2R_2 patterns. These three patterns all produced more rapid acquisition than the R_1R_0 and R_2R_0 patterns which, except for the R_1R_0 pattern for errors, were not significantly better than the R_0R_0 pattern. Thus, acquisition of R_1R_2 by pairs with the complementary R_1R_2 responses was not significantly faster than acquisition with the R_1R_1 and R_2R_2 patterns. When the two members had complementary or the same responses, however, R_1R_2 was learned significantly faster than when only one member had been trained on either R_1 or R_2. The R_1R_0 and R_2R_0 patterns were, in general, not significantly superior to the R_0R_0 pattern. Because of the high coefficient of concordance for the three measures, it seemed reasonable to estimate an overall rank order by averaging the ranks on each measure for each of the response patterns. The resultant rank order indicated decreasing rates of learning for the R_1R_2, R_1R_1, R_2R_2, R_2R_0, R_1R_0, and R_0R_0 patterns.

Under nominal conditions, while the R_1R_2, R_1R_1, and R_2R_2 patterns were learned faster than the remaining three patterns, the only statistically significant differences were those between the former three patterns and R_oR_o for errors. With this exception, there were no differences among the six patterns.

The significant interaction of the cooperative or nominal conditions with response patterns was due to faster learning of the R_1R_2 sequence under the cooperative than under the nominal conditions with patterns R_1R_2 and R_1R_1, and to slower learning under the cooperative than under the nominal condition with pattern R_2R_2, and, particularly, with patterns R_1R_o, R_2R_o, and R_oR_o. The interaction suggested that when the two members of the cooperative groups had the complementary R_1 and R_2 responses and, perhaps the supplementary R_1 and R_1 responses, they learned faster than under the nominal condition. But with the remaining four patterns, particularly when neither or only one member of the cooperative group had R_1 or R_2, the nominal condition was apparently superior. The significant interaction indicated that the profiles of the six patterns under the cooperative and nominal conditions were significantly different. Comparisons of pairs of means for each of the patterns under the cooperative and under the nominal condition, however, indicated that, on the whole, the only significant differences were those between pairs of means for the R_1R_o, R_2R_o, and R_oR_o patterns.

In addition to ascertaining the relative advantages of each of the six patterns under cooperative and nominal conditions, this study was concerned with the degree to which the obtained order of rates of learning of the R_1R_2 sequence with the six patterns under the cooperative condition corresponded to the rank order which had been hypothesized which was for successively slower learning with the R_1R_2, R_1R_1, R_2R_2, R_1R_o, R_2R_o, and R_oR_o patterns. The obtained overall rank order of R_1R_2, R_1R_1, R_2R_2, R_2R_o, R_1R_o, R_oR_o, with the exception of the reversal of the superiority of R_2R_o to R_1R_o, was consistent with that anticipated. However, as noted previously, there were few significant differences between successive adjacent pairs of means of trials, moves, and errors.

The present results can be regarded within the broader framework of transfer of training. Presupposed in the consideration which led to the hypothesized rank order are substantial net positive transfer from the prior learning of R_1 to the R_1 stage of the R_1R_2 sequence, and substantial net positive transfer from the prior learning of R_2 to the R_2 stage. Further, such transfer is not regarded as contingent on the interaction of the members of the pairs. However, under both conditions, while prior learning of R_1 might have produced positive transfer to the R_1 stage of R_1R_2 such learning might also have resulted in negative transfer to the R_2 stage. Conversely, positive transfer to the R_2 stage from prior learning of R_2 might be offset by negative transfer to the R_1 stage. Because of the equal rates of learning of R_1 and R_2 and the equated amount of R_0 experience, any transfer from nonspecific sources, presumably positive in direction, should be the same for all of the response patterns. To facilitate comparisons among the six patterns under both nominal and cooperative conditions, these hypothesized sources of transfer from learning R_1 or R_2 or from the R_0 experience to the acquisition of the R_1 and R_2 stages of the R_1R_2 sequence under each of the pattern-condition combinations have been summarized in Table 12. The presumed directions of their effects -- facilitative (+), inhibitory (-), or neutral (0) -- have also been indicated.

Whether the amount of positive transfer from R_1 to the R_1 stage differs from that from R_2 to the R_2 stage, and whether there are differences in the amounts of negative transfer from R_1 to the R_2 stage and from R_2 to the R_1 stage cannot be determined from the present data. Under the nominal condition, should Ss who had learned R_1 and R_2 have acquired the R_1R_2 sequence faster than Ss who had experienced R_0, a conclusion of net positive transfer from learning R_1 and R_2 to acquiring R_1R_2 would have been warranted. And any further differences between R_1R_1 and R_2R_2 and between R_1R_0 and R_2R_0 would have indicated whether the learning of R_1 or of R_2 had led to the greater net positive transfer. But the results indicated that under the nominal condition there were in general no differences among the six patterns.

Table 12

Summary of Effects of Transfer of Training and Interaction for Each Response Pattern under Cooperative and under Nominal Conditions

Response Pattern	S Trained in Stage	Cooperative Pairs: Transfer to: First Stage (R_1)	Cooperative Pairs: Transfer to: Second Stage (R_2)	Cooperative Pairs: Non-specific Transfer	Cooperative Pairs: Effect on Partner	Nominal Pairs: Transfer to: First Stage (R_1)	Nominal Pairs: Transfer to: Second Stage (R_2)	Nominal Pairs: Non-specific Transfer	Nominal Pairs: Effect on Partner
R_1R_2	R_1	+[1]	−	+	+	+	−	+	0
	R_2	−	+	+	+	−	+	+	0
R_1R_1	R_1	+	−	+	+	+	−	+	0
	R_1	+	−	+	+	+	−	+	0
R_2R_2	R_2	−	+	+	+	−	+	+	0
	R_2	−	+	+	+	−	+	+	0
R_1R_o	R_1	+	−	+	+	+	−	+	0
	R_o	0	0	+	−	0	0	+	0
R_2R_o	R_2	−	+	+	+	−	+	+	0
	R_o	0	0	+	−	0	0	+	0
R_oR_o	R_o	0	0	+	−	0	0	+	0
	R_o	0	0	+	−	0	0	+	0

1. Presumed Facilitative (+); Inhibitory (−); or Neutral (0) effects.

Thus for Ss who learned the R_1R_2 sequence as individuals, there was apparently no net positive transfer from learning R_1 or R_2 to acquiring the R_1R_2 sequence over and above possible positive transfer from the nonspecific sources for which R_0 provided a baseline.

One explanation for the apparent failure to obtain net positive transfer from learning R_1 to the acquisition of R_1R_2 was that any facilitative effects of the learning of R_1 on the R_1 stage were counterbalanced by negative transfer or interference from the R_2 stage. Any negative transfer from prior acquisition of R_2 to the R_1 stage might be replaced by another retarding consequence, the extinction of R_2 in order for R_1 to occur. Examination of the first three choices of the first trial of the acquisition of R_1R_2 under the nominal condition indicated that such elimination of R_2 did occur. Of the 40 Ss who had first learned R_2, all three components were the first responses of only three Ss. Only three more Ss responded with the first two components of R_2, while an additional 13 Ss made only the first of the component responses of R_2.

Under the cooperative condition there were differences in learning rates among the six patterns. These differences presumably stemmed from the interaction of members of the pairs. Accordingly, also included in Table 12 are hypothesized effects of each member of the cooperative pairs on the other member for both R_1 and R_2 stages of R_1R_2.

For the R_1R_2 pattern, in addition to the possible facilitation based on the complementary relationship between R_1 and R_2, the execution of R_1 by Ss who had learned that response might have provided some facilitation of that response for the S who had learned R_2. And the execution of R_2 by Ss who had learned R_2 might have provided some aid in performing that response for the S who had learned R_1. The most rapid acquisition might, therefore, occur with this pattern.

For the R_1R_1 and R_2R_2 patterns the opportunity for each S to observe another S make the response might have assured better retention of that response by each S of the pair. As noted previously, going from R_1 to R_2 does not require the elimination of R_2 in order for R_1 to occur, but if R_1 is to precede R_2, R_2 must be extinguished at least temporarily. Therefore, acquisition of the R_1R_2 sequence might be more rapid for R_1R_1 than for R_2R_2 pairs.

In the case of the R_1R_o and R_2R_o patterns, the S who had the R_o experience might benefit from seeing the other S respond with R_1 or R_2. But the initial errors of the S who had the R_o experience might reduce the tendencies of the other S to make R_1 or R_2. The R_1R_o and R_2R_o patterns, therefore, might be expected to produce slower learning of the R_1R_2 sequence than the R_1R_1 and R_2R_2 patterns.

For the R_oR_o pattern the opportunity for each S to see the other choose correctly might be facilitative. But this would not occur until one or the other had begun to learn the R_1R_2 sequence. Initially, neither facilitation nor inhibition of the responses of one S by the other would be expected. Slowest acquisition of the R_1R_2 sequence might occur with this pattern.

While this analysis shows that the obtained rank order of the six patterns under the cooperative condition can be accounted for in terms of possible effects of one member of the pair on the other, the analysis should not presently be accorded great importance. One reason for this is that there is little or no direct evidence of the hypothesized effects. Further, the analysis was developed after rather than before the results were known. Finally, the postulated differences among R_1R_2, R_1R_1, and R_2R_2 were not significant statistically nor, in general, were those among R_1R_0, R_2R_0, and R_0R_0.

Implications.--Previous investigations of group problem solving, particularly at the communicative level, provided no clearcut evidence of the often-presumed superiority of groups to individuals. While groups solved some problems more effectively than individuals, the same or similar problems as well as other problems were sometimes solved by groups no more or less effectively than by individuals. Some of these inconsistencies may be the consequence of differences in problems, or, more precisely, they may reflect interactions of types of problems with group or individual attempts at their solution. The results obtained in the present investigation suggest that the patterning of responses among members of groups may also interact with problem solving by groups or by individuals.

Under the group condition the complementary pattern (R_1R_2), and possibly the supplementary patterns (R_1R_1, R_2R_2) were superior to those in which only one or neither member had previously acquired the necessary response (R_1R_0, R_2R_0, R_0R_0). When compared with the performance of nominal groups, however, only the complementary and possibly one of the supplementary patterns (R_1R_1) under the cooperative condition may have been facilitative, and this possible superiority was not significant statistically. The patterns in which only one or neither member had the required response were clearly less effective under cooperative than under nominal conditions.

When the results of this study are viewed with respect to those of previous studies it seems apparent that relative proficiencies in the solution of problems by groups and by individuals is contingent upon both, the types of problems, and the patterning of relevant responses among members of groups. The obtained rank order of the six response patterns approximated the order which had been hypothesized on the basis of the patterning of strengths of responses among group members. However, until predictions can be made with formal rigor and until more than the order of effectiveness of response patterns in two-man cooperative groups can be predicted, the major value of the consideration of such patterns is largely orientative.

Summary

The primary objectives of the present study were (a) to investigate group problem solving as a function of responses of individual members when the nature and strengths of relevant responses were specified prior to Ss' participation in the group task; and (b) to compare the performance of Ss in two-man groups with that of individuals with comparable responses.

Two hundred forty male undergraduates were first assigned to three training groups and then, on the basis of previous training, either to 60 two-man cooperative groups or to 60 two-man nominal groups (pairs of Ss working individually).

Using a panel of six switches, Ss were required to learn a predetermined sequence of switch movements. Each component choice of the correct sequence was reinforced by a white light; a red light indicated the end of a sequence. Initial learning consisted of learning either R_1 or R_2, each of which consisted of selecting three switches in a particular sequence. Nonspecific sources of transfer involved in such learning were controlled by "warm-up" experience (R_o) with the switches which did not involve the strengthening of R_1 or R_2. The pairs of Ss who then learned an R_1R_2 sequence cooperatively represented the six patterns which could be formed from R_1, R_2, and R_o: R_1R_2, R_1R_1, R_2R_2, R_1R_o, R_2R_o,

R_oR_o. Under the nominal condition there were the same patterns.

Under the cooperative condition the R_1R_2, R_1R_1, and R_2R_2 patterns, in general, required significantly fewer trials, moves, and errors to criterion than did the R_1R_o, R_2R_o, and R_oR_o patterns. Under the nominal condition, although the differences among patterns were not significant, their rank order was similar to that under the cooperative condition.

The significant interaction of patterns and conditions for all three measures was due to larger means for the R_1R_2 and R_1R_1 patterns and smaller means for the R_2R_2, R_1R_o, R_2R_o and R_oR_o patterns under the nominal than under the cooperative condition. When the members of pairs who learned cooperatively had complementary R_1 and R_2 responses or supplementary R_1 and R_1 responses they may have learned faster than individuals under the nominal condition; for the remaining four patterns, the nominal condition was superior.

Under the cooperative condition increasingly slower rates of learning for the R_1R_2, R_1R_1, R_2R_2, R_1R_o, R_2R_o, and R_oR_o patterns had been anticipated. Although many of the obtained differences were not significant, the obtained rank orders of the patterns for the three response measures were, in general, consistent with that expected.

Considerations regarding the patterning of response strengths were then examined within the broader framework of presumed sources of positive and negative transfer from learning R_1 or R_2 or the R_o experience to the acquisition of R_1R_2. Possible facilitative and inhibitory effects of each member of cooperative pairs upon the other for each of the six response patterns, which might have been responsible for obtained differences among those patterns, were then considered.

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Appendix

Instructions for Learning R_1 or R_2 or the R_1R_2 Sequence and for the R_0 Experience

Learning R_1 or R_2 [1]

You see before you a series of six switches and two lights. Your task is to find the switches which will turn on the white light (demonstrate). To help you the switches are numbered from one to six. You are to pull the switches toward you using only the thumb and forefinger of your preferred hand. Your other hand is to be kept at your side. Pull the lever slowly as far as it will go. Do not switch hands.

When the white light goes off you are to find the switch which will turn it on again. If you pull the correct switch the white light will go on. Do not release this switch until the light goes off again. When the light goes off you are to try to find a switch which will now turn the light on again. Hold this switch until the white light goes off. When the light goes off you may begin to look for the next switch. You are to continue in this manner until the red light goes on (demonstrate - leave on). The red light will be used only to tell you that all the correct switches have been pulled. After the red light goes off it will be followed by the white light again (demonstrate), indicating the beginning of the next series.

For example, the white light will go on now if you pull switch number two (demonstrate). It will go on now if you pull switch number five (demonstrate). The red light (demonstrate) indicates that you have pulled all the correct switches. The white light (demonstrate - leave on) that you are to get ready to start the next series.

When the white light goes off you are to try to turn it on again by finding the correct switch and slowly pulling it toward you. You are to learn the responses which turn on the white light so that you can go directly from one correct switch to the next correct one until the red light goes on. Pay close attention to the task because you may be asked to recall it later. Do you have any questions?

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1. These instructions were also used in the preliminary experiment.

$\underline{R_o}$ Experience

You see before you a series of six switches and two lights. The switches are numbered from one to six. Your task will be to pull the switches which correspond to the numbers I call out. Some of these switches will turn on the white light (demonstrate). You are to pull the switches toward you using only the thumb and forefinger of your preferred hand. Your other hand is to be kept at your side. Pull the lever slowly as far as it will go. Do not switch hands.

When the white light goes off I will begin to call out numbers. You are to slowly pull the switches which correspond to the numbers I call out. If the white light does not go on release the switch and wait for the next number. If the white light goes on do not release the switch until it goes off again. When the light goes off I will call out the next number. Pull the switch which corresponds to this number. If the white light does not go on release the switch and wait for a number. If the light goes on hold the switch until it goes off again and wait for a number. You are to continue in this manner until the red light goes on (demonstrate - leave on). The red light will be used only to tell you that all of the correct switches have been pulled. After the red light goes out it will be followed by the white light again (demonstrate), indicating the beginning of the next series.

For example, the white light will go on now if you pull switch number two (demonstrate). It will go on now if you pull switch number five (demonstrate). The red light indicates that you have pulled all the correct switches (demonstrate). The white light (demonstrate - leave on) that you are to get ready to start the next series. When the white light goes off I will read a number to you. You are to find a switch which corresponds to the number and slowly pull it toward you.

Pay close attention to the procedure of selecting the switches and getting accustomed to the white light following some of your responses and to the red light following the end of a sequence. But do not attempt to learn any sequence of switches followed by white lights since they will vary from trial to trial. However, later you may be asked to learn some responses which turn on the white light so that you can go directly from one correct switch to the next correct one until the red light goes on. Do you have any questions?

Learning the R_1R_2 Sequence: Nominal Condition

You see before you a series of six switches and two lights. Your task is to find the switches which will turn on the white light (demonstrate). To help you the switches are numbered from one to six. You are to pull the switches toward you using only the thumb and forefinger of your preferred hand. Your other hand is to be kept at your side. Pull the lever slowly as far as it will go. Do not switch hands.

When the white light goes off you are to find the switch which will turn it on again. If you pull the correct switch the white light will go on. Do not release this switch until the light goes off again. When the light goes off you are to try to find a switch which will now turn the light on again. Hold this switch until the white light goes off. When the light goes off you may begin to look for the next switch. You are to continue in this manner until the red light goes on (demonstrate - leave on). The red light will be used only to tell you that all the correct switches have been pulled. After the red light goes off it will be followed by the white light again (demonstrate), indicating the beginning of the next series.

For example, the white light will go on now if you pull switch number two (demonstrate). It will go on now if you pull switch number five (demonstrate). The red light (demonstrate) indicates that you have pulled all the correct switches. The white light (demonstrate - leave on) that you are to get ready to start the next series.

When the white light goes off you are to try to turn it on again by finding the correct switch and slowly pulling it toward you. You are to learn the responses which turn on the white light so that you can go directly from one correct switch to the next correct one until the red light goes on. Do you have any questions?

Learning the R_1R_2 Sequence: Cooperative Condition

You see before you a series of six switches and two lights. Your task is to find the switches which will turn on the white light (demonstrate). To help you the switches are numbered from one to six. You are to pull the switches toward you using only the thumb and forefinger of your preferred hand. Your other hand is to be kept at your side. You are to work cooperatively. Do not talk to each other. Do not point to switches with your fingers. Pull only one switch at a time. Keep your hand on the table unless you intend to pull a switch. Pull the lever slowly as far as it will go. Do not switch hands.

When the white light goes off you are to find the switch which will turn it on again. If you pull the correct switch the white light will go on. Do not release this switch until the light goes off again. When the light goes off you are to try to find a switch which will now turn the light on again. Hold this switch until the white light goes off. When the light goes off you may begin to look for the next switch. You are to continue in this manner until the red light goes on (demonstrate - leave on). The red light will be used only to tell you that all the correct switches have been pulled. After the red light goes off it will be followed by the white light again (demonstrate), indicating the beginning of the next series.

For example, the white light will go on now if you pull switch number two (demonstrate). It will go on now if you pull switch number five (demonstrate). The red light (demonstrate) indicates that you have pulled all the correct switches. The white light (demonstrate - leave on) that you are to get ready to start the next series.

When the white light goes off you are to try to turn it on again by finding the correct switch and slowly pulling it toward you. You are to cooperatively learn the responses which turn on the white light so that you can go directly from one correct switch to the next correct one until the red light goes on. Do you have any questions?

Apparatus

A block diagram of the apparatus was given in Figure 1. The major elements are the S's panel, the control units (control panel, patch board, constant speed motor, and programing switches) and the recording units (recorder and recorder power supply). Figure 3 is a schematic circuit.

Subject's panel.--The S's panel consisted of six double-pole, double-throw, momentary-contact, telephone-type switches (1M-6M) which served as manipulanda, and of two 7 watt 115-125 volt candelabra type bulbs (one white and one red) which served as reinforcers. The switches could be operated in either of two directions: pulling them toward position S1 or toward position S2 (Figure 1). Only one side of the switches is shown in Figure 3. With the exception that contact is made by moving the switch in the opposite direction, the second side is a duplicate of that shown.

Control units.--Seven microswitches served as programming switches (1P-7P). These were mounted on the adaptor plate of a Gorrell and Gorrell Type MG-1000 timer. A cam driven by the constant speed motor (110 volts, 60 cycles AC) activated the switches. The arrangement of the switches and the cam is shown in Figure 4. The timer was set so that the cam made 4 rpm.

The control panel consisted of on-switches for the patch board and the motor (#1,2), the starting button (push

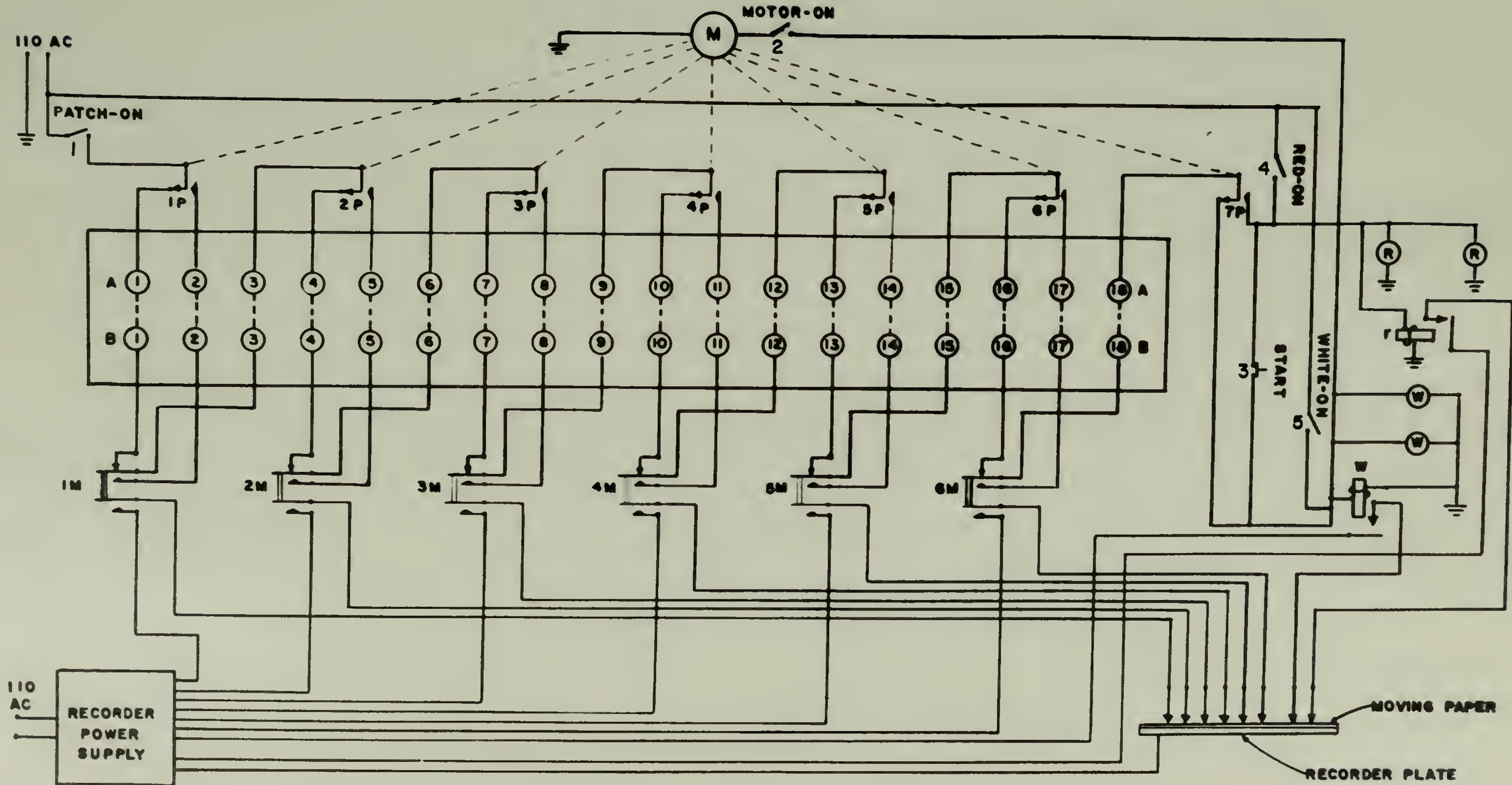

Fig. 3. Schematic circuit.

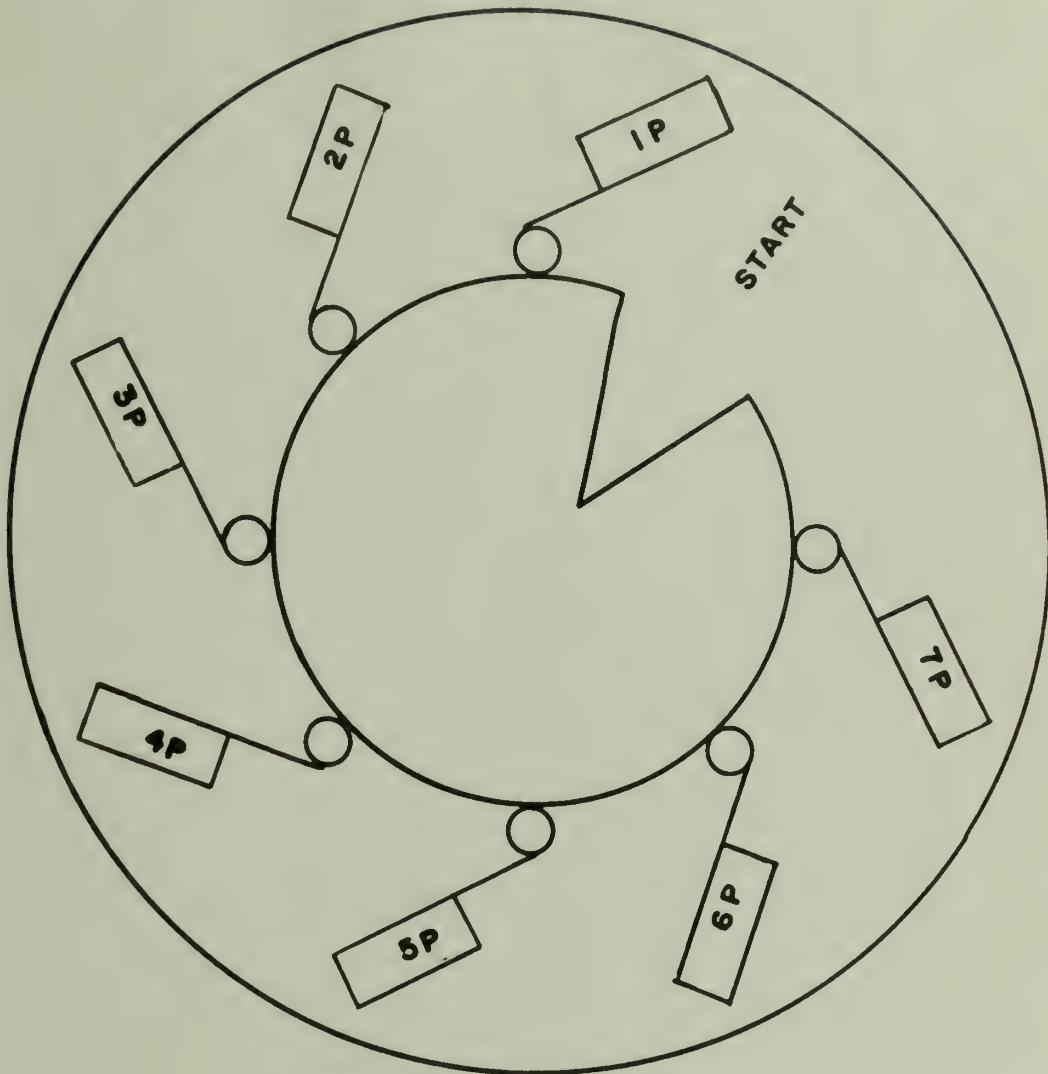

Fig. 4. Arrangement of the microswitches on the adaptor plate. The cam is shown in the starting position.

button) (#3) which was used to return the cam to the starting position after each cycle, a red light and a white light corresponding to those on the S's panel, and on-switches (#4,5) for manual control of the signal lights.

The patch board[1] was used to change the circuits between S's switches and the programing switches. This was accomplished by means of patch cords which permitted alterations of connections between the terminals of the patch board. The patch board connections shown in Figure 3 (broken lines between the terminals) require manipulation of the switches in a $1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6$ sequence for the motor to complete one cycle (from starting position to the seventh programing switch). Patch cord connections for the R_1 and R_2 training series and for the R_1R_2 sequence are given on page 69.

Recording units.--Switch movements were recorded on Gorrell and Gorrell Electrex charting paper which responds to an electric current. Speed of the paper was regulated by a Gorrell and Gorrell Type B Junior Recorder. The heads of eight sewing needles served as styli. The paper speed was 15 in. per sec. Relays w and r were used to complete the recording circuit for the white light and the red light respectively.

Operation.--Any sequence of two or more switches was

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1. A telephone switchboard served as the patch board.

Patch Cord Connections for the R_1 and R_2 Training Series and for the R_1R_2 Sequence

Sequence		
R_1 ($3 \rightarrow 2 \rightarrow 4$)	R_2 ($5 \rightarrow 4 \rightarrow 2$)	R_1R_2 ($3 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 4 \rightarrow 2$)
6A - 6B	13A - 13B	1A - 1B
7A - 7B	15A - 15B	3A - 3B
13A - 13B	16A - 16B	5A - 5B
15A - 15B	18A - 18B	7A - 7B
16A - 16B	12B - 15B	9A - 9B
17A - 17B	5B - 17A	13A - 13B
9B - 18B	2A - 18B	15A - 15B
12B - 18B	6B - 18B	16A - 16B
11B - 17A	11B - 14A	18A - 18B
5B - 14A	11A - 14B	12B - 13B
11A - 8B	10A - 12A	2A - 8B
2A - 16B	1A - 9A	6B - 18B
1A - 9A		5B - 17A
10A - 12A		11B - 14A
		8A - 11B
		11A - 14B
		10A - 12A
		4A - 6A

set into the patch board. With the cam in the starting position (Figure 4) and the motor switch closed, the apparatus was activated by closing the patch board switch (#1). This turned on the white light and started the motor which rotated the cam. When the leaf of the first microswitch (1P) dropped into the opening the circuit was broken turning off the white light and stopping the motor. By pulling the appropriate switch on his panel, S closed the circuit thus turning on the white light and activating the motor which rotated the cam to the next position. This process was repeated until the leaf of the seventh microswitch (7P) dropped into the opening, breaking the circuit for the white light and motor, and closing the circuit which turned on the red-light signal for the end of the series. The cycle was then repeated by pushing the starting button (#3).

The red and the white signal lights were turned on and off independently of switchboard and control switches by means of their respective on-switches (#4,5). With the motor switch (#2) in the on position, closing the switch for the white light activated the motor and returned the cam to the starting position.

Preliminary Experiment: Trials, Moves, Errors, and Time to Learn R_1 and R_2

Learned	Position for Learning	Subject	Total Trials	Total Moves	Total Errors	Time[1] in Seconds
R_1	1	1	4	17	5	147
		2	4	19	7	106
		3	4	13	1	76
		4	6	28	10	174
	2	5	5	21	6	119
		6	5	27	12	167
		7	5	23	8	95
		8	5	31	16	120
R_2	1	9	4	18	6	96
		10	4	18	6	119
		11	8	53	29	174
		12	5	27	12	149
	2	13	8	36	12	170
		14	7	43	22	191
		15	5	23	8	131
		16	5	25	10	118
Total			84	422	170	2152
Mean			5.25	26.38	10.63	134.50

1. Time for administration of instructions is not included. The time required to read the instructions was 2 minutes and 20 seconds.

Preliminary Experiment: Scores for Retention of R_1 and R_2[1]

Learned	Position During Learning and Re-learning	Subject	Trials to Criterion	Moves to Criterion	Errors to Criterion
R_1	1	1	0	0	0
		2	0	0	0
		3	0	0	0
		4	1	6	3
	2	5	1	6	3
		6	2	7	1
		7	1	6	3
		8	0	0	0
R_2	1	9	0	0	0
		10	0	0	0
		11	0	0	0
		12	0	0	0
	2	13	0	0	0
		14	0	0	0
		15	0	0	0
		16	0	0	0

1. Measured 10 minutes after original learning.

Preliminary Experiment: Vincent Fifths of Total Moves to Learn R_1 and R_2[1]

Subject	Fifths 1	2	3	4	5	Total
1	6.4	3.4	2.4	2.4	2.4	17
2	8.0	3.8	2.4	2.4	2.4	19
3	3.2	2.6	2.4	2.4	2.4	13
4	9.8	5.6	5.4	3.6	3.6	28
5	8.0	4.0	3.0	3.0	3.0	21
6	12.0	6.0	3.0	3.0	3.0	27
7	9.0	5.0	3.0	3.0	3.0	23
8	17.0	5.0	3.0	3.0	3.0	31
9	7.2	3.6	2.4	2.4	2.4	18
10	7.2	3.6	2.4	2.4	2.4	18
11	19.6	15.6	8.0	5.0	4.8	53
12	6.0	12.0	3.0	3.0	3.0	27
13	14.0	6.6	5.6	5.0	4.8	36
14	15.2	11.2	8.2	4.8	3.6	43
15	10.0	4.0	3.0	3.0	3.0	23
16	10.0	6.0	3.0	3.0	3.0	25
Total	162.6	98.0	60.2	51.4	49.8	422
Mean	10.2	6.1	3.8	3.2	3.1	26.4

1. Total moves in each fifth of the learning period including the criterion trials which served as the bases for determining the number of moves on each of the trials of the R_0 experience.

$\underline{R}_o$ Experience: Training Sequences

R_o-I and R_o-II series of reinforced and nonreinforced trials. Half of the $\underline{S}$s receiving the R_o experience were administered R_o-I and half R_o-II. The underlined responses were reinforced with the white light; "R" indicates reinforcement with the red light.

$\underline{R}_o$-I

Trial	Required Responses
1	$4 \rightarrow \underline{6} \rightarrow 2 \rightarrow 4 \rightarrow \underline{2} \rightarrow 5 \rightarrow 3 \rightarrow 1 \rightarrow 3 \rightarrow \underline{4} \rightarrow R$
2	$2 \rightarrow 6 \rightarrow \underline{5} \rightarrow 4 \rightarrow \underline{1} \rightarrow 2 \rightarrow \underline{6} \rightarrow R$
3	$\underline{3} \rightarrow \underline{2} \rightarrow \underline{1} \rightarrow R$
4	$\underline{5} \rightarrow \underline{6} \rightarrow \underline{1} \rightarrow R$
5	$\underline{3} \rightarrow \underline{4} \rightarrow \underline{5} \rightarrow R$

$\underline{R}_o$-II

Trial	Required Responses
1	$4 \rightarrow 6 \rightarrow \underline{2} \rightarrow 4 \rightarrow 2 \rightarrow 5 \rightarrow \underline{3} \rightarrow 1 \rightarrow 3 \rightarrow \underline{4} \rightarrow R$
2	$\underline{2} \rightarrow 6 \rightarrow 5 \rightarrow \underline{4} \rightarrow 1 \rightarrow 2 \rightarrow \underline{6} \rightarrow R$
3	$\underline{3} \rightarrow \underline{2} \rightarrow \underline{1} \rightarrow R$
4	$\underline{5} \rightarrow \underline{6} \rightarrow \underline{1} \rightarrow R$
5	$\underline{3} \rightarrow \underline{4} \rightarrow \underline{5} \rightarrow R$

<u>Counterbalancing for the Learning of R_1 and R_2</u>

Group[1]	Response Pattern	Learned or Experienced	When Learned[2]	Position[3]	Subject No. Cooperative	Subject No. Nominal	Random Series
1	R_1R_1	R_1	1	1	1	13	
	R_1R_1	R_1	2	2	2	14	
	R_1R_2	R_1	1	1	3	15	
	R_1R_2	R_2	2	2	4	16	
	R_1R_o	R_1	1	1	5	17	
	R_1R_o	R_o	2	2	6	18	I
	R_2R_2	R_2	1	1	7	19	
	R_2R_2	R_2	2	2	8	20	
	R_2R_o	R_2	1	1	9	21	
	R_2R_o	R_o	2	2	10	22	I
	R_oR_o	R_o	1	1	11	23	II
	R_oR_o	R_o	2	2	12	24	I
2	R_1R_1	R_1	1	2	25	37	
	R_1R_1	R_1	2	1	26	38	
	R_1R_2	R_2	1	2	27	39	
	R_1R_2	R_1	2	1	28	40	
	R_1R_o	R_o	1	2	29	41	II
	R_1R_o	R_1	2	1	30	42	
	R_2R_2	R_2	1	2	31	43	
	R_2R_2	R_2	2	1	32	44	
	R_2R_o	R_o	1	2	33	45	II
	R_2R_o	R_2	2	1	34	46	
	R_oR_o	R_o	1	2	35	47	I
	R_oR_o	R_o	2	1	36	48	II

1. Ten two-man groups were formed for each response pattern.
2. The order in which the <u>S</u>s of each pair were trained is designated as 1 or 2.
3. Positions 1 and 2 are indicated in Figure 1. <u>S</u>s took the same positions when learning the R_1R_2 sequence.

Group	Response Pattern	Learned or Experienced	When Learned	Position	Subject No.		Random Series
					Cooperative	Nominal	
	R_1R_1	R_1	1	2	49	61	
	R_1R_1	R_1	2	1	50	62	
	R_1R_2	R_1	1	2	51	63	
	R_1R_2	R_2	2	1	52	64	
	R_1R_o	R_1	1	2	53	65	
3	R_1R_o	R_o	2	1	54	66	I
	R_2R_2	R_2	1	2	55	67	
	R_2R_2	R_2	2	1	56	68	
	R_2R_o	R_2	1	2	57	69	
	R_2R_o	R_o	2	1	58	70	I
	R_oR_o	R_o	1	2	59	71	II
	R_oR_o	R_o	2	1	60	72	I
	R_1R_1	R_1	1	1	73	85	
	R_1R_1	R_1	2	2	74	86	
	R_1R_2	R_2	1	1	75	87	
	R_1R_2	R_1	2	2	76	88	
	R_1R_o	R_o	1	1	77	89	II
4	R_1R_o	R_1	2	2	78	90	
	R_2R_2	R_2	1	1	79	91	
	R_2R_2	R_2	2	2	80	92	
	R_2R_o	R_o	1	1	81	93	II
	R_2R_o	R_2	2	2	82	94	
	R_oR_o	R_o	1	1	83	95	II
	R_oR_o	R_o	2	2	84	96	I
	R_1R_1	R_1	1	1	97	109	
	R_1R_1	R_1	2	2	98	110	
	R_1R_2	R_1	1	1	99	111	
	R_1R_2	R_2	2	2	100	112	
	R_1R_o	R_1	1	1	101	113	
5	R_1R_o	R_o	2	2	102	114	II
	R_2R_2	R_2	1	1	103	115	
	R_2R_2	R_2	2	2	104	116	
	R_2R_o	R_2	1	1	105	117	
	R_2R_o	R_o	2	2	106	118	II
	R_oR_o	R_o	1	1	107	119	I
	R_oR_o	R_o	2	2	108	120	II
	R_1R_1	R_1	1	2	121	133	
	R_1R_1	R_1	2	1	122	134	
	R_1R_2	R_2	1	2	123	135	
	R_1R_2	R_1	2	1	124	136	
	R_1R_o	R_o	1	2	125	137	I
6	R_1R_o	R_1	2	1	126	138	
	R_2R_2	R_2	1	2	127	139	
	R_2R_2	R_2	2	1	128	140	
	R_2R_o	R_o	1	2	129	141	I
	R_2R_o	R_2	2	1	130	142	
	R_oR_o	R_o	1	2	131	143	I
	R_oR_o	R_o	2	1	132	144	II

Group	Response Pattern	Learned or Experienced	When Learned	Position	Subject No.		Random Series
					Cooperative	Nominal	
	R_1R_1	R_1	1	2	145	157	
	R_1R_1	R_1	2	1	146	158	
	R_1R_2	R_1	1	2	147	159	
	R_1R_2	R_2	2	1	148	160	
	R_1R_o	R_1	1	2	149	161	
7	R_1R_o	R_o	2	1	150	162	II
	R_2R_2	R_2	1	2	151	163	
	R_2R_2	R_2	2	1	152	164	
	R_2R_o	R_2	1	2	153	165	
	R_2R_o	R_o	2	1	154	166	II
	R_oR_o	R_o	1	2	155	167	I
	R_oR_o	R_o	2	1	156	168	II
	R_1R_1	R_1	1	1	169	181	
	R_1R_1	R_1	2	2	170	182	
	R_1R_2	R_2	1	1	171	183	
	R_1R_2	R_1	2	2	172	184	
	R_1R_o	R_o	1	1	173	185	I
8	R_1R_o	R_1	2	2	174	186	
	R_2R_2	R_2	1	1	175	187	
	R_2R_2	R_2	2	2	176	188	
	R_2R_o	R_o	1	1	177	189	I
	R_2R_o	R_2	2	2	178	190	
	R_oR_o	R_o	1	1	179	191	I
	R_oR_o	R_o	2	2	180	192	II
	R_1R_1	R_1	1	1	193	205	
	R_1R_1	R_1	2	2	194	206	
	R_1R_2	R_1	1	1	195	207	
	R_1R_2	R_2	2	2	196	208	
	R_1R_o	R_1	1	2	197	209	
9	R_1R_o	R_o	2	1	198	210	I
	R_2R_2	R_2	1	1	199	211	
	R_2R_2	R_2	2	2	200	212	
	R_2R_o	R_2	1	1	201	213	
	R_2R_o	R_o	2	2	202	214	I
	R_oR_o	R_o	1	1	203	215	I
	R_oR_o	R_o	2	2	204	216	II
	R_1R_1	R_1	1	2	217	229	
	R_1R_1	R_1	2	1	218	230	
	R_1R_2	R_2	1	2	219	231	
	R_1R_2	R_1	2	1	220	232	
	R_1R_o	R_o	1	1	221	233	II
10	R_1R_o	R_1	2	2	222	234	
	R_2R_2	R_2	1	2	223	235	
	R_2R_2	R_2	2	1	224	236	
	R_2R_o	R_o	1	2	225	237	II
	R_2R_o	R_2	2	1	226	238	
	R_oR_o	R_o	1	2	227	239	II
	R_oR_o	R_o	2	1	228	240	I

Table of Raw Data: Learning of R_1 and R_2

Distribution of trials, moves, and errors to criterion in the learning of R_1 and R_2 for Ss subsequently assigned to one of six response patterns and to one of ten groups under cooperative or nominal conditions. Ss subjected to the R_o experience chose different sets of switches on each trial.

Trials to Criterion for Ss Subsequently Assigned to Cooperative Condition

Subsequent Response Pattern	Subject	Learned	Group 1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	2	1	3	1	7	1	1	1	1	2
	B	R_2	2	2	2	1	1	2	8	1	6	1
R_1R_1	A	R_1	2	3	1	1	7	1	1	4	5	2
	B	R_1	2	2	1	2	1	2	1	14	2	2
R_2R_2	A	R_2	8	5	2	3	1	4	2	2	2	2
	B	R_2	1	3	1	2	1	2	1	2	2	1
R_1R_o	A	R_1	1	8	1	2	8	2	2	1	2	1
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	1	2	3	1	2	1	2	4	3	5
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

Trials to Criterion for Ss Subsequently Assigned to Nominal Condition

Subsequent Response Pattern	Subject	Learned	Group									
			1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	5	3	1	3	3	1	1	1	2	2
	B	R_2	2	2	1	2	2	1	4	2	2	3
R_1R_1	A	R_1	3	5	2	5	1	1	25	1	2	6
	B	R_1	2	2	2	5	5	1	4	6	2	1
R_2R_2	A	R_2	1	1	1	3	2	2	2	5	2	3
	B	R_2	4	7	3	2	2	2	2	4	2	1
R_1R_o	A	R_1	2	4	1	2	5	7	3	1	5	2
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	1	2	5	1	3	19	2	1	4	2
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

Moves to Criterion for Ss Subsequently Assigned to Cooperative Condition

Subsequent Response Pattern	Subject	Learned	Group									
			1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	17	8	23	10	24	7	10	6	9	17
	B	R_2	15	16	15	8	8	21	70	13	36	12
R_1R_1	A	R_1	15	17	6	6	48	7	10	96	57	18
	B	R_1	13	15	10	13	8	17	10	27	17	12
R_2R_2	A	R_2	40	35	14	25	11	30	17	18	19	16
	B	R_2	12	20	11	16	14	16	11	18	15	8
R_1R_o	A	R_1	12	51	11	18	71	11	15	13	14	12
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	14	14	27	11	16	14	24	38	31	33
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

<u>Moves</u> <u>to</u> <u>Criterion</u> <u>for</u> <u>Ss</u> <u>Subsequently</u> <u>Assigned</u> <u>to</u> <u>Nominal</u> <u>Condition</u>

Subsequent Response Pattern	Subject	Learned	Group									
			1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	23	17	8	28	21	9	8	9	13	14
	B	R_2	18	12	14	18	15	10	25	17	11	32
R_1R_1	A	R_1	27	25	15	43	10	10	200	14	16	62
	B	R_1	14	17	14	28	38	12	18	53	15	10
R_2R_2	A	R_2	9	11	9	25	18	19	15	46	14	33
	B	R_2	41	64	23	16	12	17	17	31	18	14
R_1R_o	A	R_1	14	35	9	16	41	54	24	13	47	16
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	14	18	42	10	18	146	15	12	47	17
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

Errors to Criterion for Ss Subsequently Assigned to Cooperative Condition

Subsequent Response Pattern	Subject	Learned	Group									
			1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	11	5	14	7	3	4	7	3	6	11
	B	R_2	9	10	9	5	5	15	46	10	18	9
R_1R_1	A	R_1	9	8	3	3	27	4	7	54	42	12
	B	R_1	7	9	7	7	5	11	7	15	11	6
R_2R_2	A	R_2	16	20	8	7	8	18	11	12	13	10
	B	R_2	9	11	8	10	11	10	8	12	9	5
R_1R_o	A	R_1	9	27	8	12	47	5	9	10	8	9
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	11	8	18	8	10	11	18	26	22	18
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

Errors to Criterion for Ss Subsequently Assigned to Nominal Condition

Subsequent Response Pattern	Subject	Learned	Group 1	2	3	4	5	6	7	8	9	10
R_1R_2	A	R_1	8	8	5	19	12	6	5	6	7	8
	B	R_2	12	6	11	12	9	7	13	11	5	23
R_1R_1	A	R_1	18	10	9	28	7	7	125	11	10	44
	B	R_1	8	11	8	13	23	9	6	35	9	7
R_2R_2	A	R_2	6	8	6	16	12	13	9	31	8	24
	B	R_2	29	43	14	10	6	11	11	19	12	11
R_1R_o	A	R_1	8	23	6	10	26	33	15	10	32	10
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_2R_o	A	R_2	11	12	27	7	9	39	9	9	35	11
	B	R_o	-	-	-	-	-	-	-	-	-	-
R_oR_o	A	R_o	-	-	-	-	-	-	-	-	-	-
	B	R_o	-	-	-	-	-	-	-	-	-	-

Table of Raw Data: Learning the R_1R_2 Sequence

Distribution of trials, moves, and errors to criterion in the learning of the R_1R_2 sequence for Ss subsequently assigned to one of six response patterns and to one of ten groups under cooperative or nominal conditions.

Trials to Criterion: Cooperative Condition

Group	Response Pattern					
	R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
1	1	2	3	8	7	4
2	4	2	3	9	11	8
3	1	1	3	6	11	4
4	1	2	5	4	5	14
5	10	6	5	7	14	11
6	2	2	7	16	7	20
7	2	6	1	14	10	6
8	3	4	10	4	2	4
9	5	5	3	14	3	10
10	1	7	3	15	5	9
Total	30	37	43	97	75	90

Trials to Criterion: Nominal Condition

Group	Subject	Response Pattern											
		R_1R_2		R_1R_1		R_2R_2		R_1R_o		R_2R_o		R_oR_o	
		X	$\bar{X}$	X	$\bar{X}$	X	$\bar{X}$	X	$\bar{X}$	X	$\bar{X}$	X	$\bar{X}$
1	A	2	2.5	5	7.0	4	4.0	5	3.0	3	4.0	9	8.0
	B	3		9		4		1		5		7	
2	A	2	5.5	2	2.0	5	4.5	3	2.5	1	5.5	11	9.5
	B	9		2		4		2		10		8	
3	A	4	3.5	6	6.0	2	2.5	3	3.0	11	6.5	2	8.0
	B	3		6		3		3		2		14	
4	A	2	2.0	1	1.5	2	2.0	15	9.5	1	2.5	3	5.0
	B	2		2		2		4		4		7	
5	A	12	7.0	3	3.0	7	6.0	2	6.5	2	2.5	12	7.5
	B	2		3		5		11		3		3	
6	A	2	2.5	1	3.5	1	1.5	4	3.5	5	4.0	2	5.0
	B	3		6		2		3		3		8	
7	A	1	2.5	19	10.0	11	9.0	8	7.0	3	3.0	3	3.5
	B	4		1		7		6		3		4	
8	A	2	2.5	1	1.5	4	3.0	6	4.5	1	4.0	2	1.5
	B	3		2		2		3		7		1	
9	A	6	8.5	5	3.0	6	3.5	4	7.0	4	3.0	6	3.5
	B	11		1		1		10		2		1	
10	A	1	3.0	4	3.0	5	3.5	2	3.5	2	5.5	6	6.5
	B	5		2		2		5		9		7	
Total			39.5		40.5		39.5		50.0		40.5		58.0

Moves to Criterion: Cooperative Condition

Group	Response Pattern					
	R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
1	10	26	39	94	81	54
2	38	27	47	84	116	114
3	8	18	43	56	135	64
4	16	22	65	38	54	133
5	77	61	52	78	174	122
6	15	20	65	163	64	226
7	18	47	15	129	92	71
8	36	41	106	52	48	63
9	51	45	36	150	37	101
10	11	66	30	133	71	90
Total	280	373	498	977	872	1038

Moves to Criterion: Nominal Condition

Group	Subject	R_1R_2 X	R_1R_2 $\bar{X}$	R_1R_1 X	R_1R_1 $\bar{X}$	R_2R_2 X	R_2R_2 $\bar{X}$	R_1R_o X	R_1R_o $\bar{X}$	R_2R_o X	R_2R_o $\bar{X}$	R_oR_o X	R_oR_o $\bar{X}$
1	A	16	28.0	57	65.5	40	42.0	58	34.0	35	48.5	112	94.5
	B	40		74		44		10		62		77	
2	A	19	48.5	20	23.0	49	58.0	37	33.0	20	64.5	189	144.5
	B	78		26		67		29		109		100	
3	A	37	39.0	64	63.0	27	28.5	27	34.5	128	77.5	24	92.0
	B	41		62		30		42		27		160	
4	A	27	27.5	14	20.0	23	22.5	131	100.0	18	30.5	39	62.5
	B	28		26		22		69		43		86	
5	A	141	83.5	40	40.0	72	55.5	27	82.0	33	41.0	135	89.5
	B	26		40		39		137		49		44	
6	A	20	27.0	24	40.5	13	22.0	65	55.0	75	55.0	31	49.5
	B	34		57		31		45		35		68	
7	A	12	31.5	210	112.0	119	95.5	103	87.0	44	38.0	41	49.0
	B	51		14		72		71		32		57	
8	A	16	23.5	17	22.5	44	33.5	53	47.5	19	61.0	27	23.5
	B	31		28		23		42		103		20	
9	A	66	94.0	48	31.5	45	30.5	41	78.5	49	33.0	59	37.5
	B	122		15		16		116		17		16	
10	A	20	46.0	41	33.5	46	37.0	18	43.0	36	71.0	61	67.0
	B	72		26		28		68		106		73	
Total			448.5		451.5		425.0		594.5		520.0		709.5

Errors to Criterion: Cooperative Condition

Group	Response Pattern					
	R_1R_2	R_1R_1	R_2R_2	R_1R_o	R_2R_o	R_oR_o
1	4	14	21	46	39	30
2	14	15	29	30	50	66
3	2	12	25	20	69	40
4	10	10	35	14	24	49
5	17	25	22	36	90	56
6	3	8	23	67	22	106
7	6	11	9	45	32	35
8	18	17	46	28	36	39
9	21	15	18	66	21	41
10	5	24	12	43	41	36
Total	100	151	240	395	424	498

Errors to Criterion: Nominal Condition

Group	Subject	Response Pattern											
		R_1R_2		R_1R_1		R_2R_2		R_1R_o		R_2R_o		R_oR_o	
		X	$\overline{X}$	X	$\overline{X}$	X	$\overline{X}$	X	$\overline{X}$	X	$\overline{X}$	X	$\overline{X}$
1	A	4	13.0	27	23.5	16	18.0	28	16.0	17	24.5	58	46.5
	B	22		20		20		4		32		35	
2	A	7	15.5	8	11.0	19	31.0	19	18.0	14	31.5	123	87.5
	B	24		14		43		17		49		52	
3	A	13	18.0	28	27.0	15	13.5	9	16.5	62	38.5	12	44.0
	B	23		26		12		24		15		76	
4	A	15	15.5	8	11.0	11	10.5	41	43.0	12	15.5	21	32.5
	B	16		14		10		45		19		44	
5	A	69	41.5	22	22.0	30	19.5	15	43.0	21	26.0	63	44.5
	B	14		22		9		71		31		26	
6	A	8	12.0	18	19.5	7	13.0	41	34.0	45	31.0	19	19.5
	B	16		21		19		27		17		20	
7	A	6	16.5	96	52.0	53	41.5	55	45.0	26	20.0	23	28.0
	B	27		8		30		35		14		33	
8	A	4	8.5	11	13.5	20	15.5	17	20.5	13	37.0	15	14.5
	B	13		16		11		24		61		14	
9	A	30	43.0	18	13.5	9	9.5	17	36.5	25	15.0	25	17.5
	B	56		9		10		56		5		10	
10	A	14	28.0	17	15.5	16	16.0	6	22.0	24	38.0	25	28.0
	B	42		14		16		38		52		31	
Total			211.5		208.5		188.0		294.5		277.0		362.5

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